

COGNITIVE ASSESSMENT DURING LONG-DURATION SPACE FLIGHT

May 2011

Robert Kane, PhD, Washington DC

Kim Seaton, PhD, University of Texas Medical Branch

Walter Sipes, PhD, Johnson Space Center

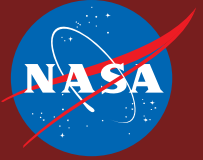
Disclosure Information

82nd Annual Scientific and Human Performance Meeting
Robert Kane, Ph.D.

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.

Outline



- Background
- Implementation
- Defining off-nominal performance
- Overview of data from space
- Way forward

Background



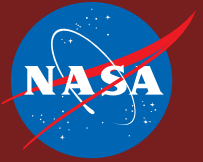
A recognized gap - no objective measure of cognitive performance was available in space operations

Mir operations indicated a need for cognitive/performance assessment.

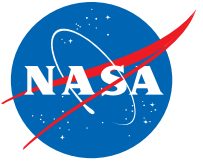
- work overload / underload
- on-board fire - contaminated air
- decompression - loss of module
- dangerous atmosphere (ethylene glycol and contaminant leaks)
- depression/withdrawal

A tool was needed that required minimal interaction with ground controllers due to communication limitations

Program Objective

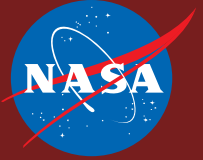


- Therefore a tool was developed - Spaceflight Cognitive Assessment Tool for Windows (WinSCAT)
- Purpose is to provide ISS flight surgeons with an objective clinical tool to monitor the astronauts' cognitive status during long-duration space flight and allow immediate feedback to the astronaut
- Developed for medical operations at NASA's Johnson Space Center in Houston, Texas



Implementation

Implementation



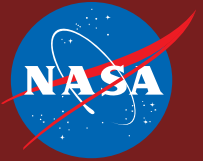
WinSCAT is a medical requirement for all long-duration missions

A computer-based, self-administered battery of five cognitive assessment subtests

In-flight tests scheduled monthly and compared against individual preflight baseline level of performance

Implemented with U.S.O.S. (United States Operational Segment) astronauts from one NASA/Mir mission and all expeditions to date (24) on the International Space Station (ISS).

WinSCAT Protocol for ISS



1. Pre-Mission: Six one-half hour sessions for baseline data collection to:
 - Overcome learning effects
 - Develop individual baseline
2. During Mission: Medically required @ 30 days:
 - Maintain proficiency & update on-orbit baseline
 - May take as often as desired for self-assessment
3. Post-Mission: Minimum one session (R+30)
 - Check the re-adaptation to 1G before return to flight status (additional administrations as medically needed)




WinSCAT: Spaceflight Cognitive Assessment Tool for on-orbit assessment of cognitive status.


WinSCAT Sign In

Welcome to WinSCAT

Enter 4-character ID

New User

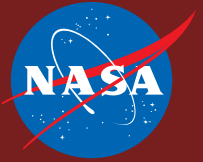




Language Preference: English

OK Cancel

Viewing Results



- Test session is immediately scored, and all tests can be reviewed by the astronaut
- Off-nominal tests appear in red
- Monthly scores are downlinked to Behavioral Health & Performance Group
- Repeat testing may occur if off-nominal
- After a traumatic/medical event (0), WinSCAT testing would be indicated – contributes to medical decisions

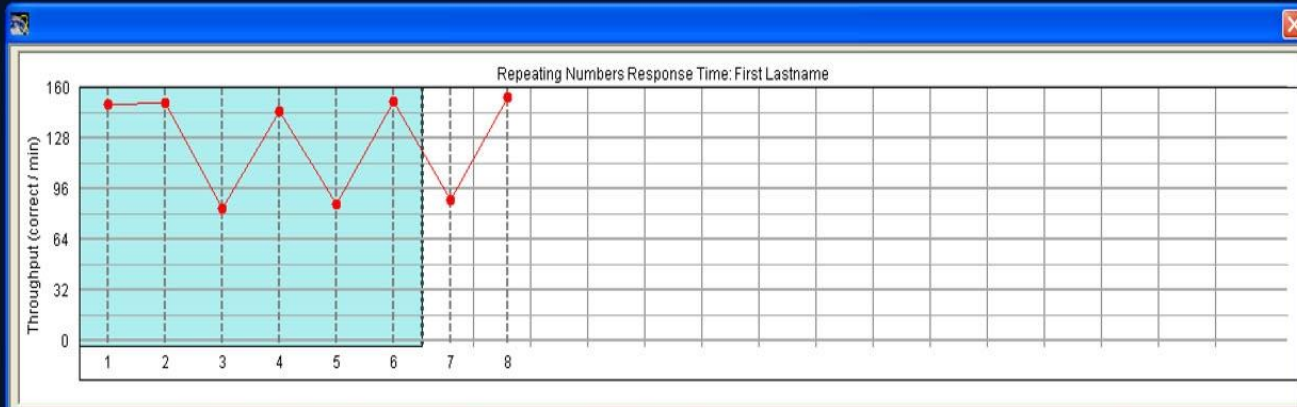


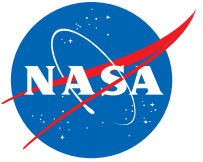
C:\Documents and Settings\All Users\Application Data\WinSCAT\Data\1111\1111.log

				Symbol Memory (Learning)				Repeating Numbers				Mathematical Processing				Pattern Matching				Symbol Memory (Memory)			
Run	Date	Time	ICE	ACC	TPUT	LAPSE	RT	ACC	TPUT	LAPSE	RT	ACC	TPUT	LAPSE	RT	ACC	TPUT	LAPSE	RT	ACC	TPUT	LAPSE	RT
1	07/19/10	08:54	567	100.00	94.12	0	637	99.44	149.81	0	398	100.00	26.50	0	2264	100.00	41.11	0	1460	100.00	80.09	0	749
2	07/22/10	09:46	547	98.61	81.95	0	723	98.89	151.03	0	393	100.00	25.40	0	2362	100.00	43.45	0	1381	94.44	51.75	0	1068
3	07/27/10	09:55	398	98.61	46.59	0	1264	91.67	86.24	7	628	95.00	18.08	0	3127	100.00	48.88	0	1228	80.56	34.44	0	1419
4	07/27/10	10:08	525	100.00	79.88	0	751	99.44	146.25	0	408	100.00	22.49	0	2668	100.00	43.17	0	1390	100.00	65.16	0	921
5	07/28/10	11:20	381	97.22	52.40	0	1121	91.67	88.34	10	600	75.00	11.24	4	3490	100.00	47.60	0	1261	91.67	39.67	0	1396
6	07/28/10	09:42	532	97.22	83.23	0	699	98.33	152.21	0	388	95.00	20.43	0	2832	90.00	43.94	0	1130	97.22	61.86	0	921
7	07/29/10	07:30	408	97.22	51.15	0	1147	91.06	91.24	11	574	95.00	17.64	0	3202	100.00	47.89	0	1253	97.22	54.67	0	1041
8	07/29/10	10:27	539	95.83	72.38	0	795	98.89	154.30	0	383	100.00	23.11	0	2596	95.00	49.09	0	1155	94.44	60.98	0	929

Session number (* indicates session with instructions)

Click a column to graph





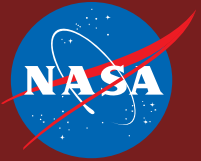
Defining off-nominal performance

Rules Comparison



- Initial Scoring Rules
 - Based on validation study at the University of Northern Colorado
 - Change for accuracy and response time scores were based on a fixed baseline composed of last 3 preflight tests
- New Scoring Rules
 - Based on combining data from different studies incorporating initial data and data from studies using 6 baseline trials
 - Off-nominal based on atypical frequency of change value
 - Change for accuracy and throughput measured against moving baseline
 - Incorporates a summary score based on weighted throughput

Approaches To Assessing Change



I. Reliable Change Index

- **SE_m**: Standard error of measurement
- **S_{diff}**: Standard error of difference score
- **r**: Test-retest reliability
- **M₂, M₁**: Mean of T2 test score , Mean of T1 test score respectively
- **S₁**: Standard deviation of control group, normal population
- **RC**: 90% confidence interval

$$SE_m = s_1 \sqrt{1-r}$$

$$S_{diff} = \sqrt{2(SE_m)^2}$$

$$RC = \pm 1.64 * S_{diff}$$

$$Mean_Change = M_2 - M_1$$

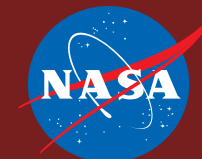
$$Correction_factor = Rounded(Mean_Change)$$

$$Adjusted_RC = Rounded(Correction_factor + RC)$$

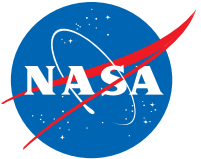
II. Regression Equation: allows for adding different sources of variation

III. Frequency (normative) based

Normative Group for WinSCAT Battery



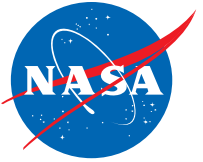
Measure		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Code Substitution (N = 129)							
TP	Mean(Sd)	50.30(10.18)	51.50(10.36)	54.51(11.44)	56.00(11.53)	57.48(11.76)	57.14(11.54)
RT	Mean(Sd)	1207(278)	1186(280)	1125(274)	1094(332)	1070(311)	1064(298)
Acc	Mean(Sd)	96.79(2.94)	97.31(2.34)	97.27(9.62)	96.67(2.96)	96.99(2.77)	96.08(3.52)
Running Memory CPT(N=115)							
TP	Mean(Sd)	97.29(20.85)	110.83(23.38)	115.17(22.39)	118.62(22.54)	120.38(23.26)	122.58(23.24)
RT	Mean(Sd)	567(112)	529(112)	511(103)	496(95)	492(98)	480(93)
Acc	Mean(Sd)	86.69(7.79)	92.66(5.76)	93.62(5.07)	94.09(4.30)	94.69(4.37)	94.31(4.96)
Mathematical Processing (N =109)							
TP	Mean(Sd)	25.89(6.58)	27.64(7.98)	27.00(7.22)	28.52(7.17)	31.51(7.60)	31.57(7.11)
RT	Mean(Sd)	2135(423)	2073(481)	2092(480)	1976(453)	1845(426)	1821(410)
Acc	Mean(Sd)	88.89(8.71)	90.59(8.63)	89.91(8.31)	89.76(7.59)	92.52(7.06)	92.16(7.31)
Matching to Sample (N=128)							
TP	Mean(Sd)	36.42(10.65)	38.57(11.77)	39.77(13.65)	37.87(11.63)	39.02(14.10)	39.29(13.36)
RT	Mean(Sd)	1608(430)	1559(436)	1557(454)	1607(478)	1568(496)	1555(517)
Acc	Mean(Sd)	92.97(6.86)	94.43(6.68)	95.31(6.11)	94.23(7.02)	93.80(6.16)	94.06(6.91)
Code Substitution Recognition (N =127)							
TP	Mean(Sd)	43.72(12.78)	39.84(11.40)	47.42(12.21)	50.32(12.90)	51.85(13.24)	44.72(12.84)
RT	Mean(Sd)	1276(400)	1361(407)	1178(303)	1122(274)	1123(281)	1191(310)
Acc	Mean(Sd)	88.06(11.98)	86.74(11.46)	90.33(10.24)	90.99(9.34)	92.73(7.81)	86.48(11.93)

**Table 1. Passing criteria (cut scores)**

Test	Throughput (change from baseline mean)	Accuracy (% correct responses)	Lapses (trials that time out with no responses)
Code sub (learning)	> -7	> 94	<1
Code sub (recall)	> - 15	> 80	<1
Running Memory CPT (repeating numbers)	> -8	> 88	<5
Matching to Sample	> -8.5	> 85	<1
Mathematical Processing	> -5	>80	<2
ICE score must be no less than 36 less than mean of baseline sessions Moving Baseline for all baseline comparisons			

Table 2. Overall session score

Score	Descriptor	Criteria	Color
0	Nominal	All scores passed AND ICE within expected range	green
1	Marginal	One score failed AND ICE within expected range	yellow
2	Off-Nominal	Two or more scores failed OR ICE below expected range	red



Overview of data from space

Analysis

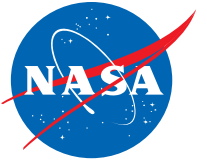


- ISS performance data were assessed to compare initial to modified interpretation rules for detecting potential changes in cognitive functioning in space flight.
- Applying the newly derived rules to ISS data (172 total test sessions) resulted in 158 nominal test sessions (92%) and 14 off-nominal performances at various times during flight.
- Performance data from ISS missions do not indicate significant cognitive decrements due to microgravity/space flight alone but has shown decrements.

Assessment

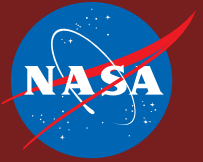


- Explanations for off-nominal performances have included fatigue, post slam shifting, distraction of life events on Earth, distraction during testing, or minimal effort on the cognitive testing (obtained from post-mission debriefings).
- Correlation to actual events is needed.



Way Forward

Refine Decision Rules



- Correlation to actual events is needed
- Challenge studies to further refine change score analysis
- Continue assessment using space flight data with incorporation of additional change metrics

Modifications



WinSCAT has been updated to add network capability to support a 6-person crew on the station support computers.

WinSCAT Version 2.0.28 has increased difficulty of items in Mathematics, increased number of items in Match-To-Sample, incorporates a moving rather than fixed baseline, and implements stricter interpretation rules.

